SELECTIVE WIRELESS TELEGRAPHY.

A PAPER by Dr. Alex. Muirhead and myself, on some experiments and measurements in accurate wireless tuning with open-circuit radiators, and the conditions under which perfect selection is possible, was read to the Royal Society in January of this year, and will appear in a forthcoming issue of the Proceedings.

The essence of it is that in signalling across land both radiator and receiver must be completely insulated from, and elevated above, the earth, if they are to be persistent oscillators such as are capable of accurate tuning. Earth connection damps out the vibration and spoils tuning: and to get the best effect the lower capacity area must be not only insulated, but must be elevated above the earth until its capacity with respect to the upper aërial is a minimum.

To prove this, the received energy was measured at a distant station by a Duddell hot-wire meter; and several series of measurements were taken with the lower capacity at different heights above the earth, and also when connected with the earth.

The sensitiveness of a thoroughly tuned Lodge-Muirhead system is extreme; small power is sufficient, and the inductive connection of the collector to the receiving instrument may be separated by a surprising interval without stopping communication.

Under these non-earthed conditions every other station, even near and powerful ones, can be tuned out and their disturbance eliminated.

Directly earth connection is made, tuning of the radiator and collector is nearly gone, for they no longer have any persistent free vibration period. Samples of a large number of measurements are recorded in the paper.

But from the paper as originally sent in an account of the most striking experiment to illustrate the facility and perfection of tuning on this system, when insulated capacity areas are employed without any earth connection, was accidentally omitted, though it has since been communicated to the society. The experiment was made on May 14, 1907, and may be briefly described.

Preliminary Information.

Each aërial of the Lodge-Muirhead system consists of a pair of capacity areas in the form of a couple of very open "Maltese crosses" or squares of wire suspended horizontally from four posts like the framework of a carpet, one above the other, and both well insulated from the earth. Connection with each is made in the middle by a special elaborately stranded cable to the instruments, but no earth connection is made at all.

A wheel coherer—revolving steel disc dipping into oiled mercury—is employed as detector under the conditions of accurate tuning; or sometimes a point coherer, similarly treated with oil. An electrolytic coherer is even more sensitive, but its leakage damps vibrations out and prevents the accumulation of impulses necessary for accurate tuning, whereas the film of oil on the wheel coherer insulates until the oscillations in the receiving tuned condenser circuit have mounted up sufficiently to break it down and overflow through the detector.

That is in brief summary the way signalling works, and the following account has reference to signalling across Kent between Elmer's End and Downe.

Experiment in Diplex Telegraphy.

At two stations, Downe and Elmer's End respectively, the upper capacity area of each aërial was bisected diagonally, the two triangular halves being insulated from each other, and each connected to its own independent receiving or sending arrangement. The lower aërial was not bisected, but was doubled, an additional insulated area being placed a few feet below the ordinary one. By this means each station was practically doubled, and the two halves at each station made to correspond to a different wave-length.

Two senders at Elmer's End were then set to work simultaneously, one to transmit the word "Liverpool" continuously for a long time, the other the word "steamships" continuously in the same way. Two independent receivers at the Downe station—one of them a siphon recorder and one a telephone, though both might easily have been automatic recorders—each of them inductively connected with one half of the aërial there, now received simultaneously, one of them a succession of "Liverpools," the other a succession of "steamships," without the slightest confusion or interference or overlapping of any kind.

In other words, diplex telegraphy (as distinct from duplex) was found quite easy on this system of tuning, which was specified by one of us in 1897.

Experiment in Selection or Tuning Out.

Another experiment more recently tried is the following. Two stations were arranged at Downe, 1200 feet apart, either of which could speak with great ease to Elmer's End, and was strong enough to speak to a station thirty miles away. One of the Downe stations was then switched on to "receiving," and both Elmer's End and the other station at Downe were set speaking to it.

The wave-length of one was 300 metres, of the other 660 metres, so as to compare Civil with Admiralty conditions.

By the mere motion of a handle the frequency of the receiving station could be altered at will so as to correspond either with the neighbouring sending station 1200 feet off, or with the distant sending station seven miles off—which distance might, however, have been increased immensely without any difficulty. A few trees intervened between the neighbouring stations.

In these circumstances, when properly adjusted, each station could be heard separately; that is to say, messages could be received first from one tuned-in station and then from the other, without any disturbance from the station tuned-out, although both stations were sending all the time strongly and simultaneously. The ease and large margin with which selection could be achieved shows that the two neighbouring stations could have been put still nearer, while still retaining the power of complete tuning-out.

Testing of Margin of Selection.

Further experiments in the same direction were conducted as follows:—

The two stations at Downe, 400 yards apart, were rearranged so that there were no trees between, only a few low hedges, thus making the test manifestly more severe. A given power was then employed for sending at one of these neighbouring stations, and the same power at the distant Elmer's End station, while the other neighbouring station was arranged for receiving from either of these two at pleasure. Experiment was now directed to determine the conditions under which the neighbouring station could be completely cut out, while still the distant one could be clearly heard. In other words, to determine the amount of separation between the primary and secondary of the inductive connection which would eliminate all disturbance from the neighbouring station adjusted to ordinary commercial wave-length, while it would permit perfect signals to be received on the siphon recorder from the distant tuned station of longer or more nearly naval wave-length.

Case 1.—Elmer's End sending with a wave-length of 580 metres. Neighbouring Downe sending with a wave-length of 300 metres. The receiving Downe station was attuned so as to cover a range of wave-length about 580 metres on the average, but extending more than 20 metres above and below. Under these conditions it was possible completely to cut out the local station on a coupling of $3\frac{1}{2}$ inches, that is, with $3\frac{1}{2}$ inches separating primary and secondary coil of the inductive connection; whereas from Elmer's End perfect signals could be obtained without disturbance on any coupling between $3\frac{1}{2}$ inches and 7 inches. Indeed, as the exact pitch was reached at the receiving adjustment, the signals received boomed out, as it were, very strongly.

Case 2.—The Elmer's End wave-length was shortened to 510 metres, the local Downe station remaining at 300 metres, and again a series of readings was taken at the receiving Downe station adjusted to an average of 510 metres wave-length.

The coupling separation, which now just managed to cut out the local station, was 4 inches. Anything above

4 inches gave perfect signals from Elmer's End, and no disturbance.

Case 3.—On shortening the distant wave-length still more, so as to make it 450 metres, the neighbouring station could not be completely cut out without at the same time introducing a trace of superposed disturbance into the messages received from the distant station.

Case 4.—The difference of wave-length between the two stations was now, therefore, again slightly increased, the Elmer's End wave-length being adjusted to 480 metres, with the local station still remaining at 300.

In this case perfect and strong signals could be received from Elmer's End again, but the separation of the inductive connection had to be as much as 6 inches in order completely to cut out the local signals from the neighbouring station.

It follows, therefore, that when two powerful stations are so excessively near each other as they were in this case—namely, in adjoining fields—a distant signal can be heard with perfect clearness, *i.e.* without any trace of disturbance, only when its wave-length is more than half as great again as that of the neighbouring station; but that undisturbed signalling is much more easy when it approaches double that magnitude, or, of course, when the neighbouring stations are not quite so close together.

In no case was any trace of harmonic detected; *e.g.* when a station was sending 300 metres, and the neighbouring receiving station was attuned to 600 metres, it did not necessarily feel any disturbance. The waves emitted and received by these radiators appear to be practically pure. OLIVER LODGE.

MARINE BIOLOGY IN THE TORTUGAS.[1]

THE volumes referred to below contain a series of nineteen papers based on work done or material collected at the Marine Biological Laboratory of the Carnegie Institution, situated on Loggerhead Key, off the south-west coast of Florida. The observations recorded bear ample testimony to the exceptionally favourable situation of the laboratory for the prosecution of marine biological research, and also to the facilities afforded on a liberal scale for work on a wide variety of subjects.

Dr. A. G. Mayer, the director of the laboratory, describes the annual breeding swarm of the Atlantic palolo (*Eunice fucata*, Ehlers), which occurs within three days of the day of the last quarter of the moon between June 29 and July 28. The worm when mature (and immature worms take no part in the swarming) is about 10 inches long, and its sexual products are limited to its posterior half. Before sunrise on the day of the annual breeding swarm the worm crawls out backwards from its burrow in the coral or limestone rock until the whole of the sexual portion is protruded. By means of vigorous twisting movements this portion is detached, swims vertically upwards to the surface of the water, and there continues to swim about with its posterior end in front. These sexual portions of the worms, which show no tendency to congregate, are present in great abundance at Tortugas, scarcely a square foot of the surface above the coral reefs being free from them. At sunrise the worms undergo violent contractions, which cause the expulsion of the sexual products through rents or tears which are formed in the body wall; the torn and shrivelled remains of the body wall then sink down to the bottom and die. Although light is probably a contributory cause, it is not the sole cause of this spasm of contraction, which takes place, though it is somewhat delayed, in swimming worms which have been removed to a dark room. After casting off its posterior sexual segments the anterior part of the worm crawls back into its burrow, and regenerates a new sexual end. The author has attempted to determine the nature of the stimulus to which the worm responds when it swarms, and he shows that the worms never swarm when moonlight is prevented from falling upon the rocks in which they are ensconced. The paper is a most interesting contribution to the study of this remarkable phenomenon.

Dr. Mayer describes a series of experiments on the scyphomedusan *Cassiopea xamachana*, from which he concludes that the stimulus which causes pulsation is due to the constant formation of sodium oxalate in the terminal endoderm cells of the marginal sense organs. The sodium oxalate precipitates calcium as calcium oxalate, thus setting free sodium chloride, which he shows acts as a nervous and muscular stimulant. Pulsation is thus caused by the constant maintenance at the nervous centres in the sense organs of a slight excess of sodium over and above that found in the surrounding sea-water.

The late Prof. W. K. Brooks and Mr. B. McGlone have studied the origin of the lung of Ampullaria. They find that the gills, the lung, and the osphradium arise simultaneously, or nearly so, that they are developed from a ridge or thickening of the mantle, and that they should therefore be regarded as a series of homologous organs specialised among themselves in different directions. The lung becomes functional before the gill, as is shown by the fact that the newly hatched young quickly die if they are prevented from leaving the water, while adults can survive an immersion of a month or more. Other papers, the last productions of the late Prof. Brooks, contain a discussion of the subgenus Cyclosalpa, a description of the rare *Salpa floridana* (Apstein), and of a new appendicularian—*Oikopleura tortugensis*—to the tail of some of which a new species of Gromia was found attached.

Prof. Reighard discusses the significance of the conspicuousness of the coral-reef fishes of the Tortugas. He concludes, as the result of a long series of ingenious experiments, that the coral-reef fishes do not possess that combination of conspicuousness, with unpleasant attributes, necessary to the theory of warning coloration. The conspicuousness of these fishes, since it is not a secondary sexual character and has no necessary meaning for protection, aggression, or as warning, is without biological significance. These fishes have no need of either aggressive inconspicuousness, because they feed chiefly on fixed invertebrates, or of protective inconspicuousness, for they are afforded abundant protection by the reefs and their own agility. Selection has therefore not acted on their colours or other conspicuous characters, but these have developed, unchecked by selection, through internal forces. An attempt is made to apply this conclusion to the "warning coloration" of conspicuous insects.

There are other memoirs on the formation of chromosomes in various echinoderm ova; on the spermatogenesis of the "walking-stick" phasmid, *Aplopus mayeri*, in which the history of the accessory chromosome is traced and its probable significance as a sex determinant discussed; on the habits and reactions of the crab *Ocypoda arenaria*, of Aplopus, and of the woody and sooty terns; on the early development of the scyphozoon Linerges, on actinian larvæ referable to the genera Zoanthella and Zoanthina; on the rate of regeneration in Cassiopea; on regeneration of the chelæ of Portunus, on the life-history of the booby and man-o'-war bird, and on the cestodes of the Tortugas.

[1] Papers from the Tortugas Laboratory of the Carnegie Instituti n of Washington. Vol. i., pp. v+191; vol. ii., pp. v+325. (Washington: Carnegie Institution, 1908.)

THE RELEVANCE OF MATHEMATICS.

ONE of the most important achievements of the thought of the last fifty years has been the conclusive proof of the logical nature of all mathematical conceptions and methods, in opposition to Kant's view that mathematical reasoning is not strictly formal, but always uses *a priori* intuitions of space and time. This does not, of course, imply that the methods of investigation followed by individual mathematicians are essentially different from those followed by other inquirers, the objects of whose researches are not purely logical; it is well known, in fact, that, though a proposition A may logically imply a proposition B, yet B may be deduced from A by considerations quite outside those of logic. Thus the existence of the solution of a certain important and famous mathematical problem—known as "Dirichlet's principle"—was, we may say, *felt*, and actually applied in domains of pure mathematics, for certain physical reasons connected with the equilibrium of statical electricity long before rigorous logical methods were discovered for proving the existence in question. The fact that propositions are